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Kinetic behaviour of biomass mixtures during torrefaction and steam gasification

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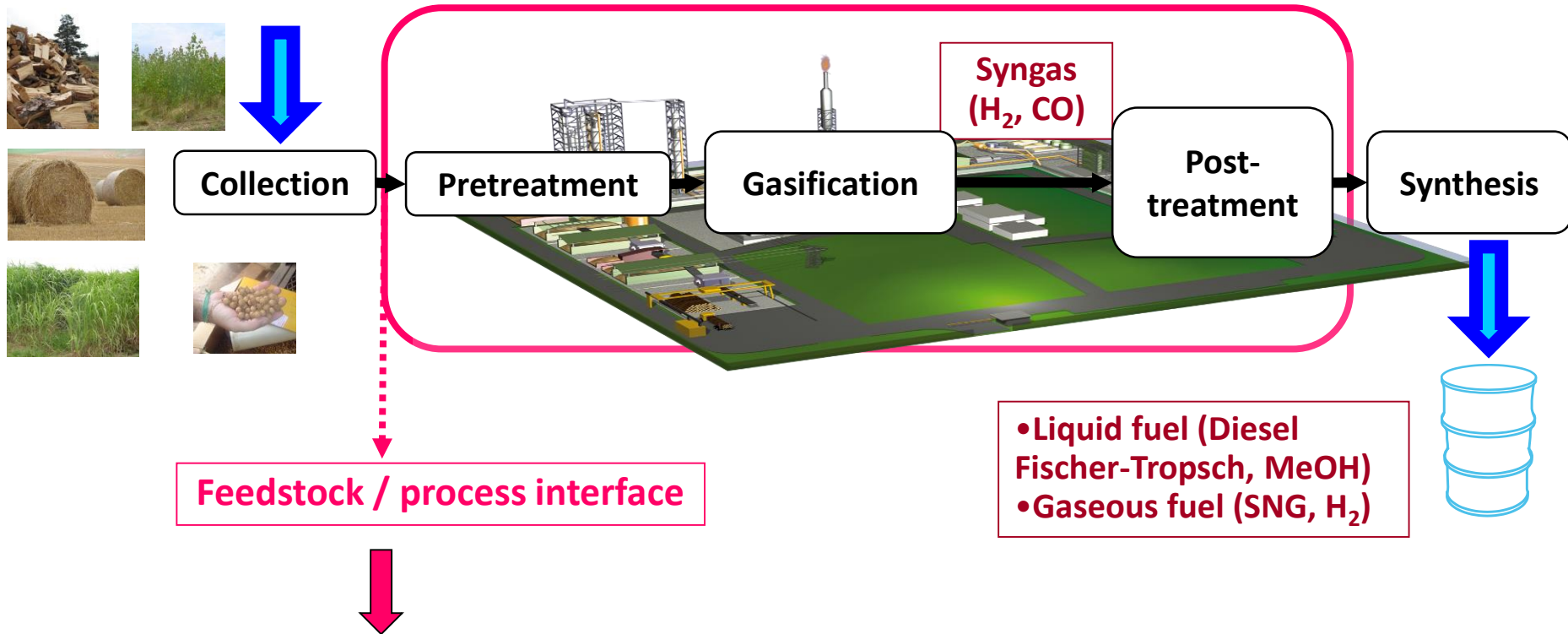
Kinetic behaviour of biomass mixtures during torrefaction and steam gasification

*E. Rodriguez Alonso, C. Dupont, D. Da Silva
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*BIOENERGY IV CONFERENCE
Tuesday, 12th June 2013*

The process: from biomass to fuel

Lignocellulosic biomass



Suitability is crucial for industrialization

Feedstock/process suitability

- To improve feedstock/process suitability → two issues:

- Quantity

- Limited
- Can vary along the year

- Quality

- Properties intrinsically variable
- Can vary along the year

SOLUTION?

A solution: biomass blends

Biomass blends



Reactor design



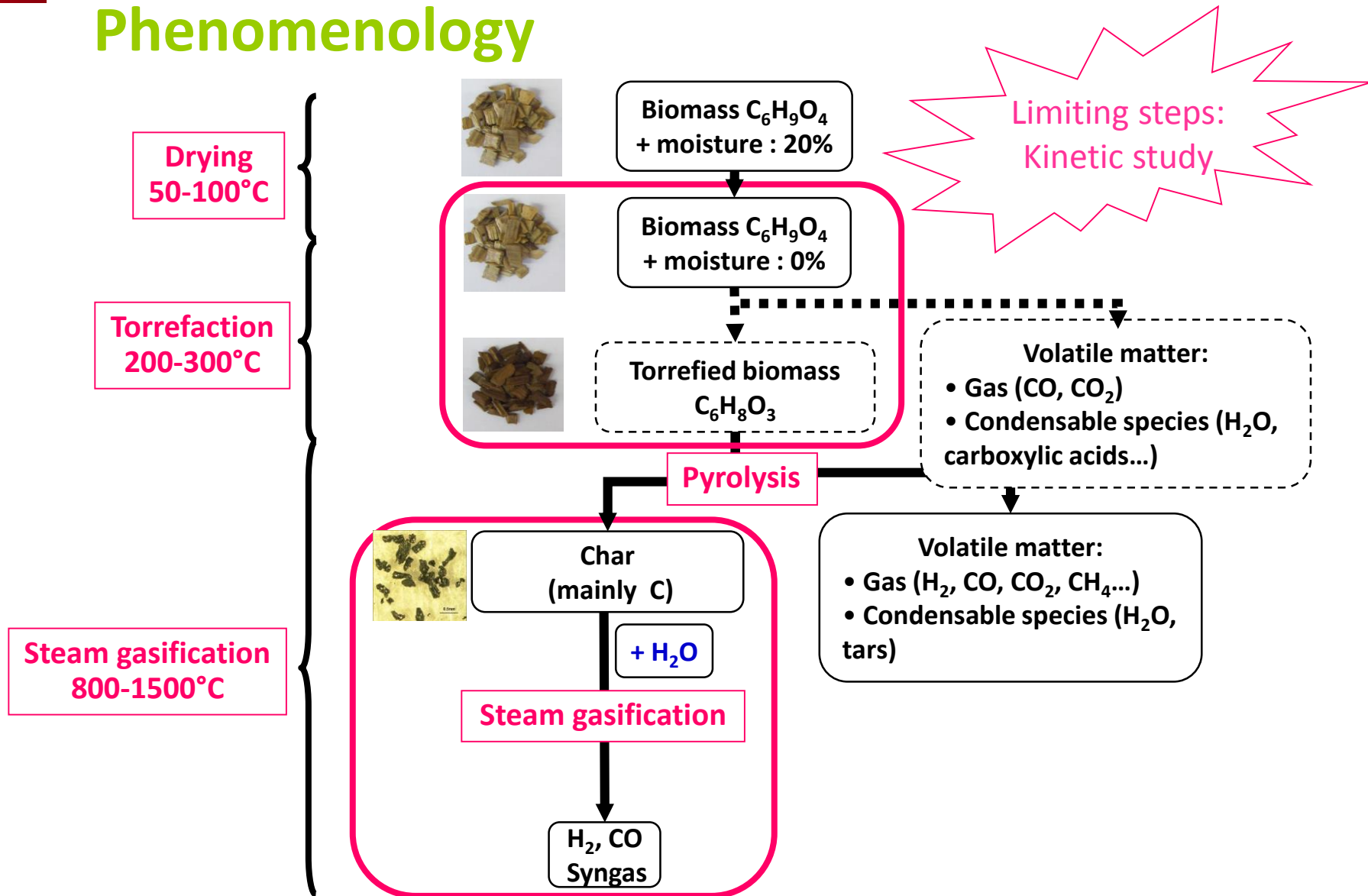
REQUIREMENT

Feedstock thermal behaviour

Nevertheless... so far:

- No characterization
 - No modelling
- } of thermal behaviour of biomass blends

Phenomenology



Objective and working plan

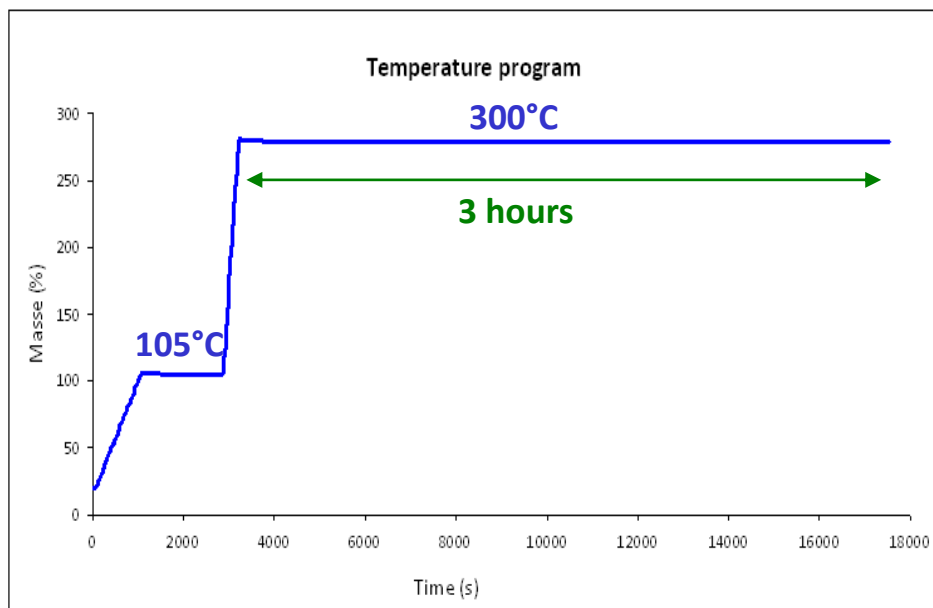
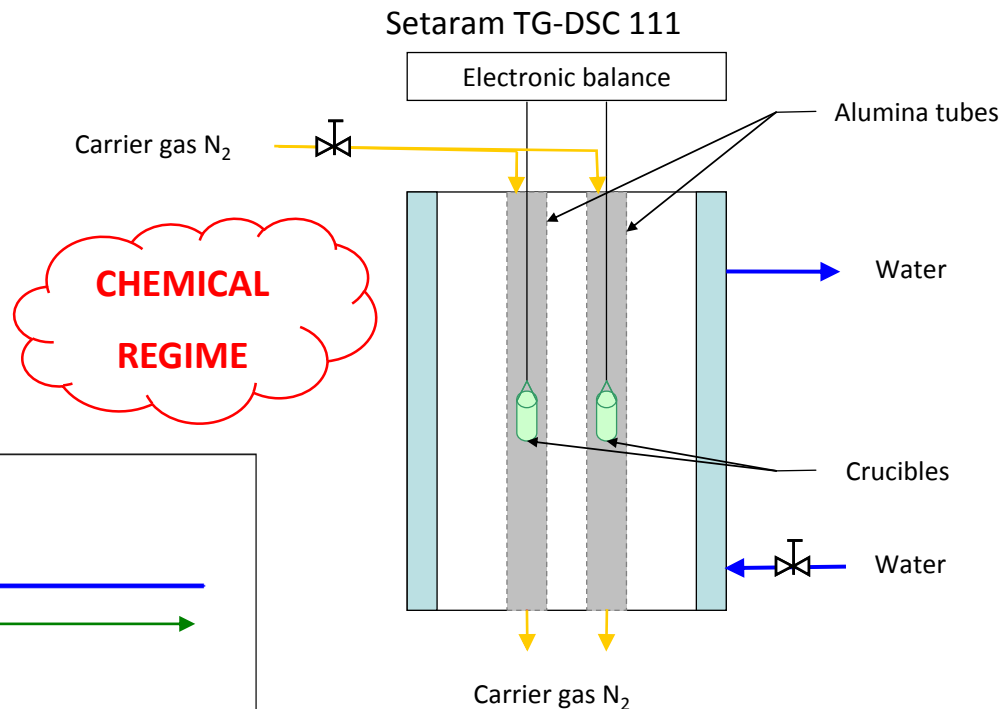
➤ Objective:

- study biomass blends kinetics during torrefaction and steam gasification of char
- check existence/lack of additive law

➤ Working plan:

- Lab-scale experimentation → thermobalance
 - Torrefaction → non-reactive atmosphere
 - Steam gasification → reactive atmosphere
- Kinetic modelling

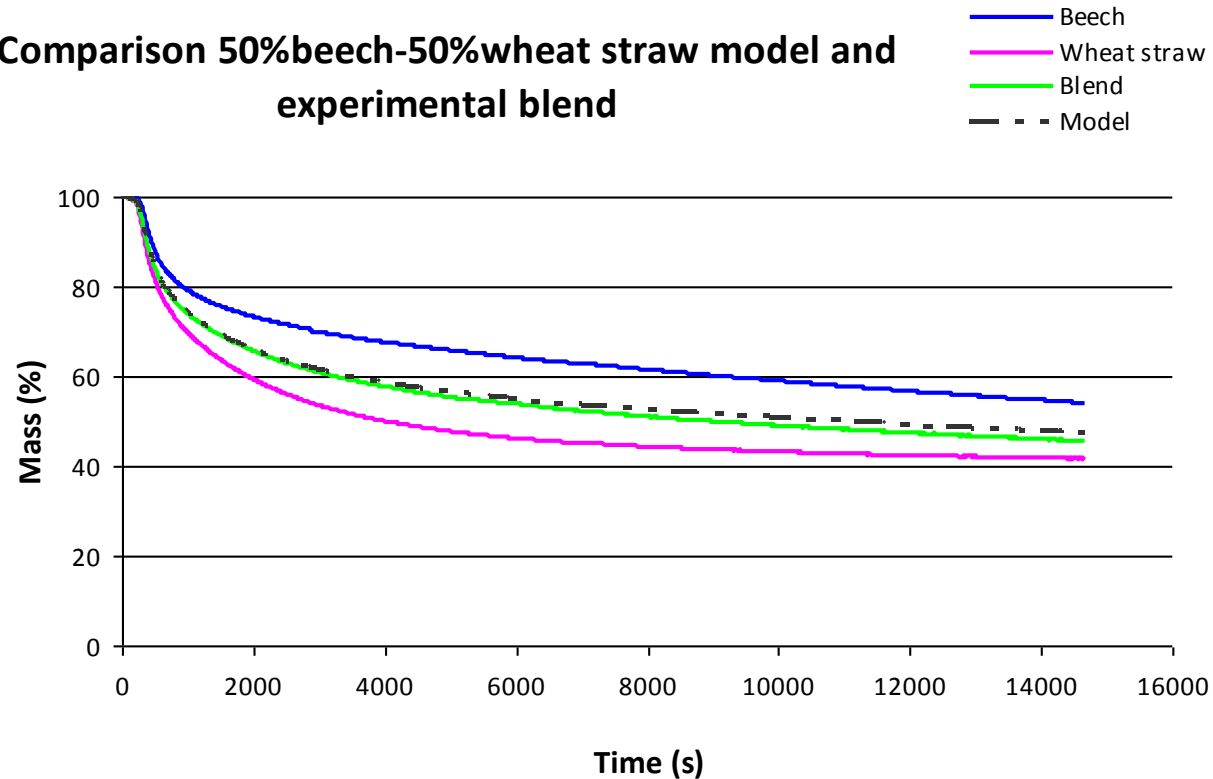
Torrefaction: experimental device



Sample nature	Beech/ wheat straw blend
Blend ratio	25/75, 50/50, 75/25
Sample mass	5 mg
Particle size	<200 μ m
Flow gas	N_2

Torrefaction: kinetic modelling

Comparison 50%beech-50%wheat straw model and experimental blend

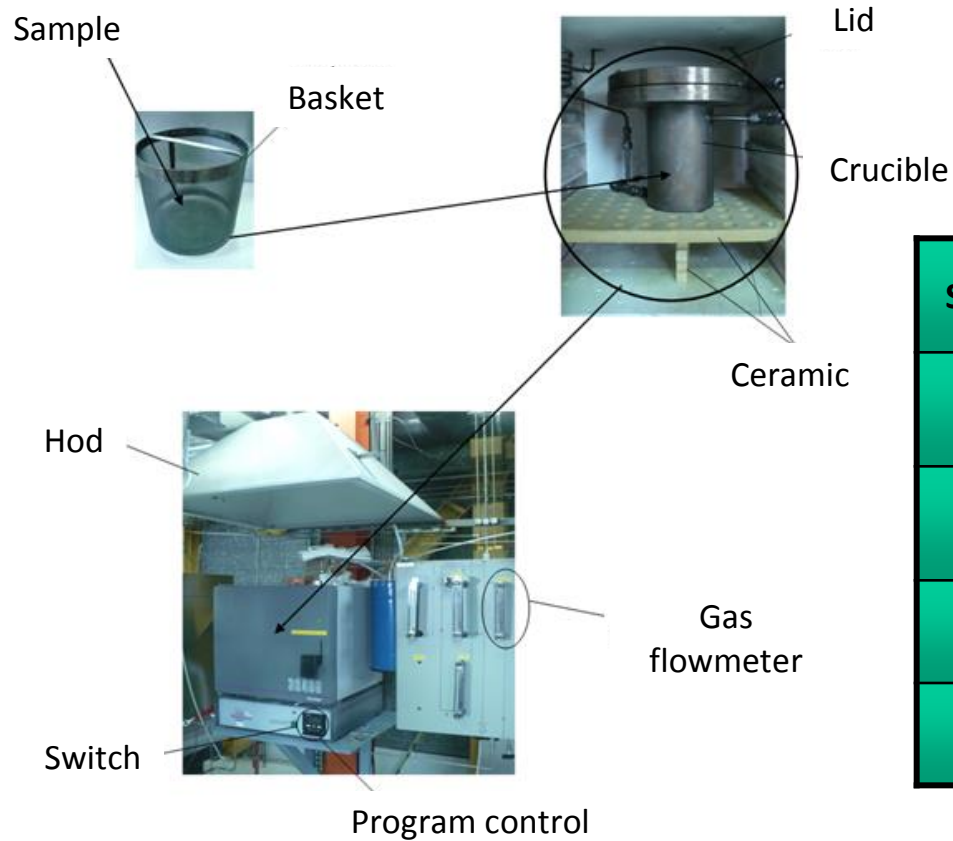


$$\Delta m_{\text{BLEND}} = \Delta m_{\text{BIOMASS 1}} \cdot \%_{\text{BIOMASS 1}} + \Delta m_{\text{BIOMASS 2}} \cdot \%_{\text{BIOMASS 2}}$$

**ADDITIVE
LAW**



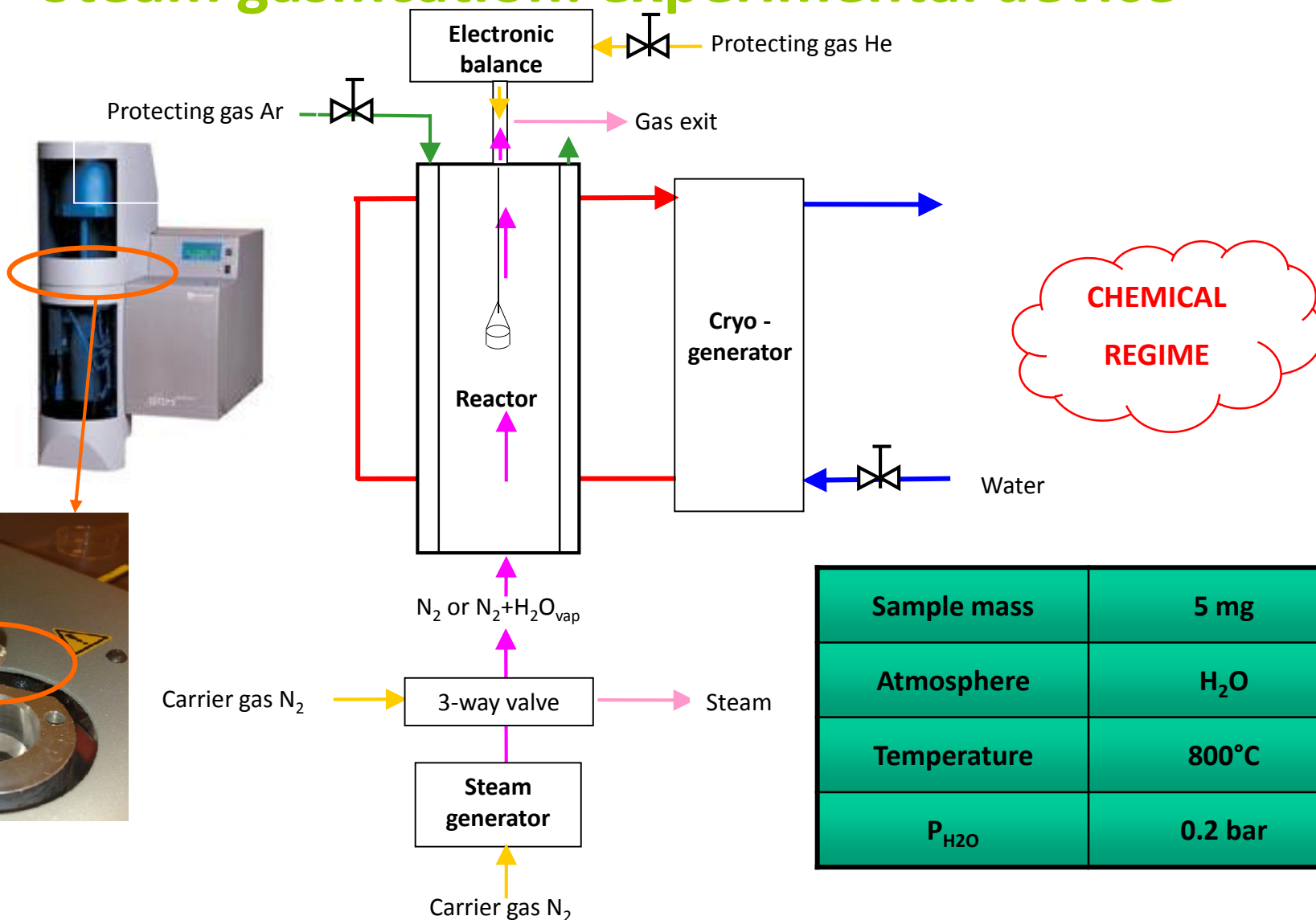
Steam gasification: experimental device



Slow pyrolysis

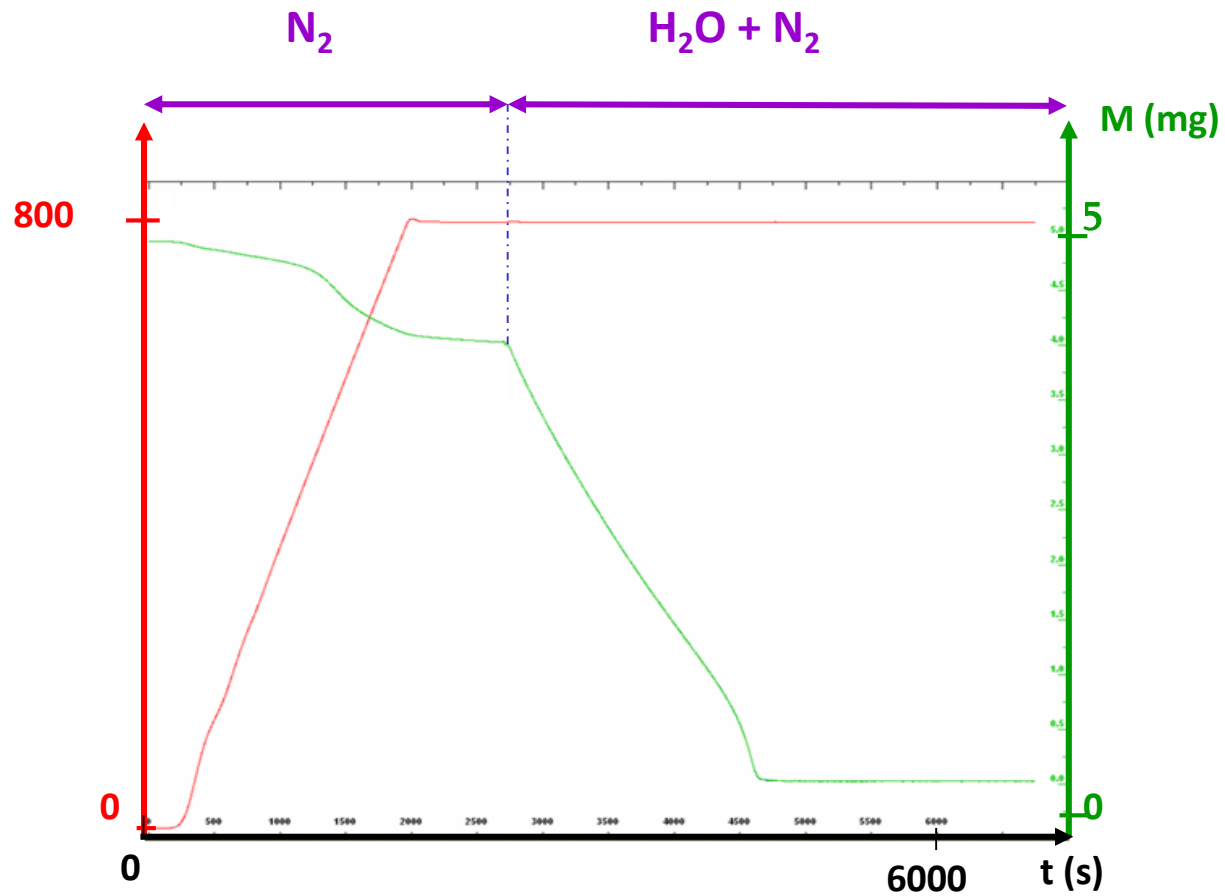
Sample nature	Beech/ wheat straw blend
Blend ratio	25/75, 50/50, 75/25
Temperature	450°C
Time	4h
Flow gas	N ₂

Steam gasification: experimental device



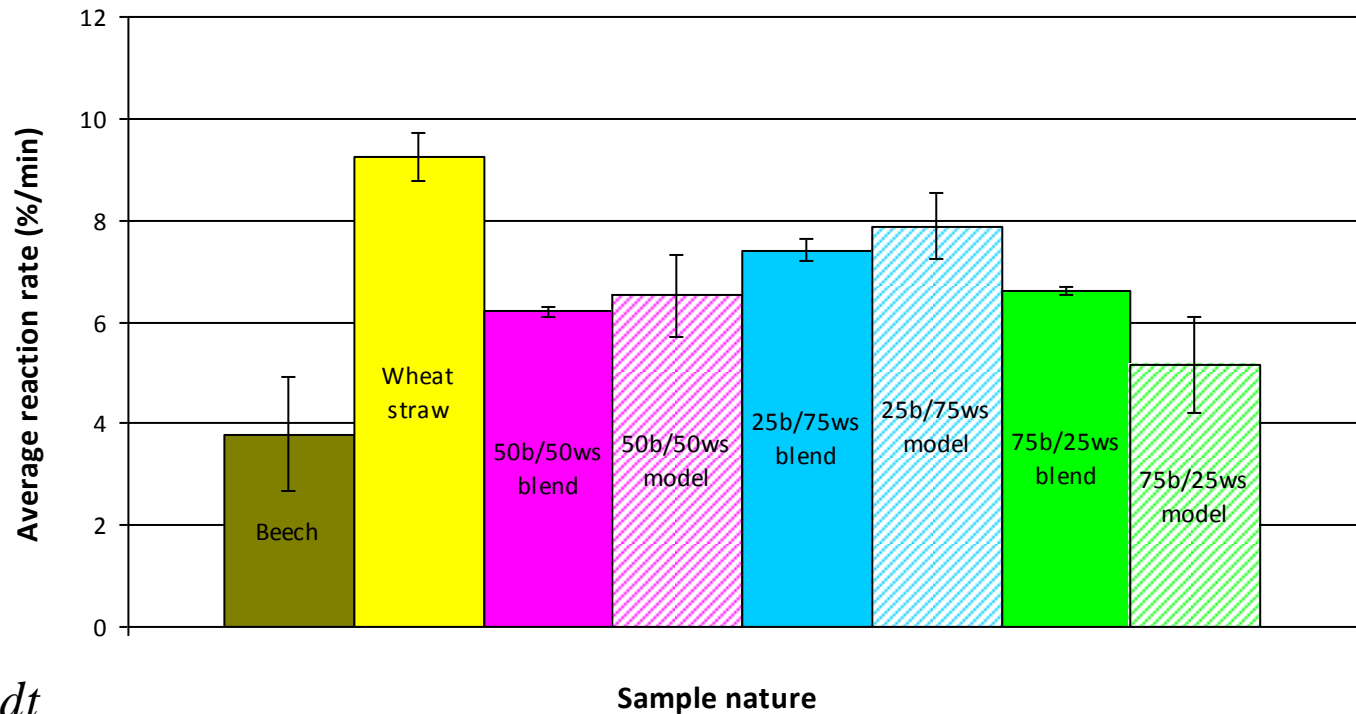
Sample mass	5 mg
Atmosphere	H ₂ O
Temperature	800°C
P _{H2O}	0.2 bar

Steam gasification: experimental device



Steam gasification: kinetic modelling

Average reaction rate 1-80%

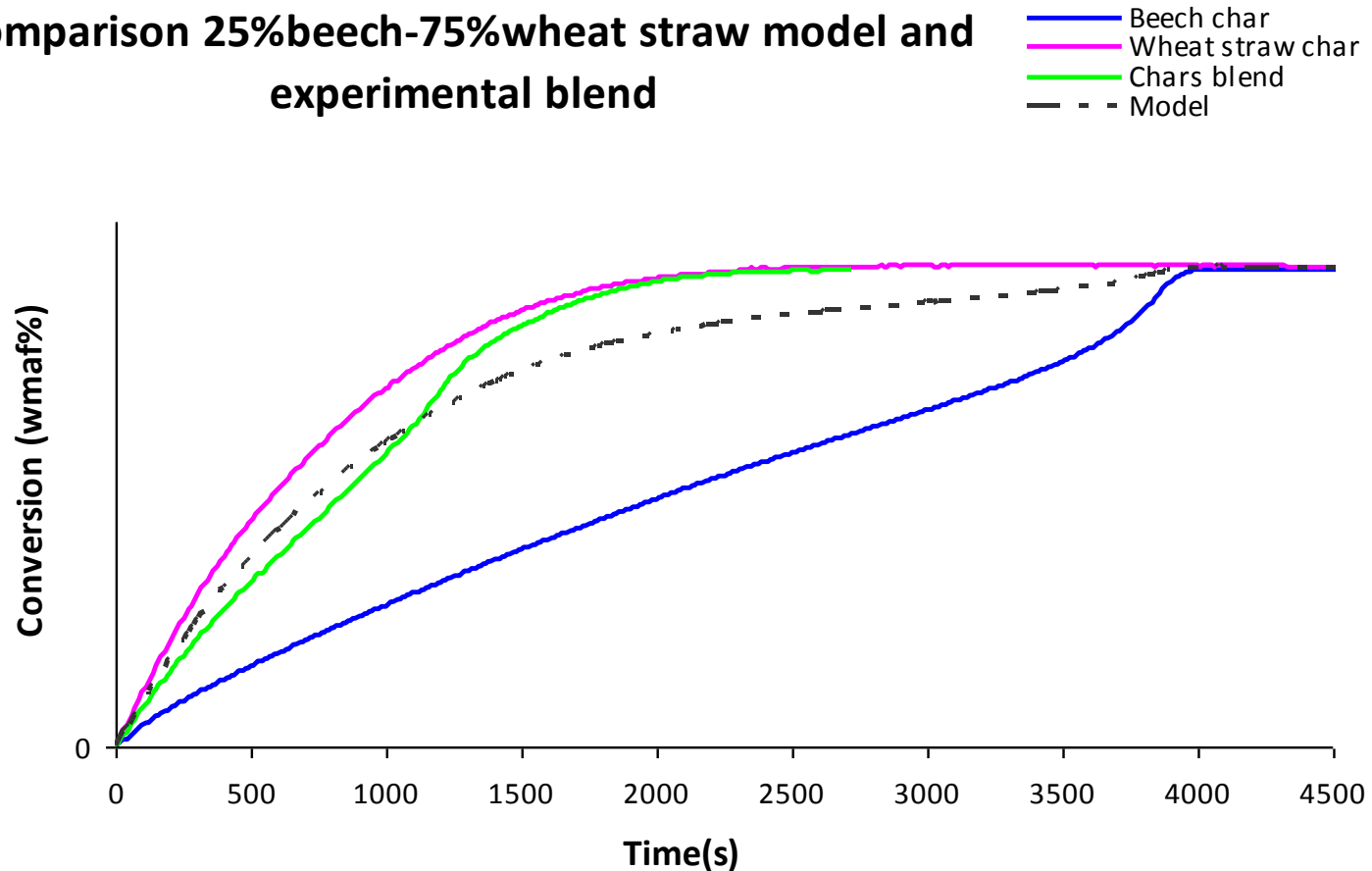


$$r_{1-80\%} = \frac{\int_{t_{X=0,01}}^{t_{X=0,80}} \frac{r(t)dt}{1-X(t)}}{t_{X=0,80} - t_{X=0,01}}$$

ADDITIVE LAW → globally valid... ✓

Steam gasification: kinetic modelling

Comparison 25%beech-75%wheat straw model and experimental blend



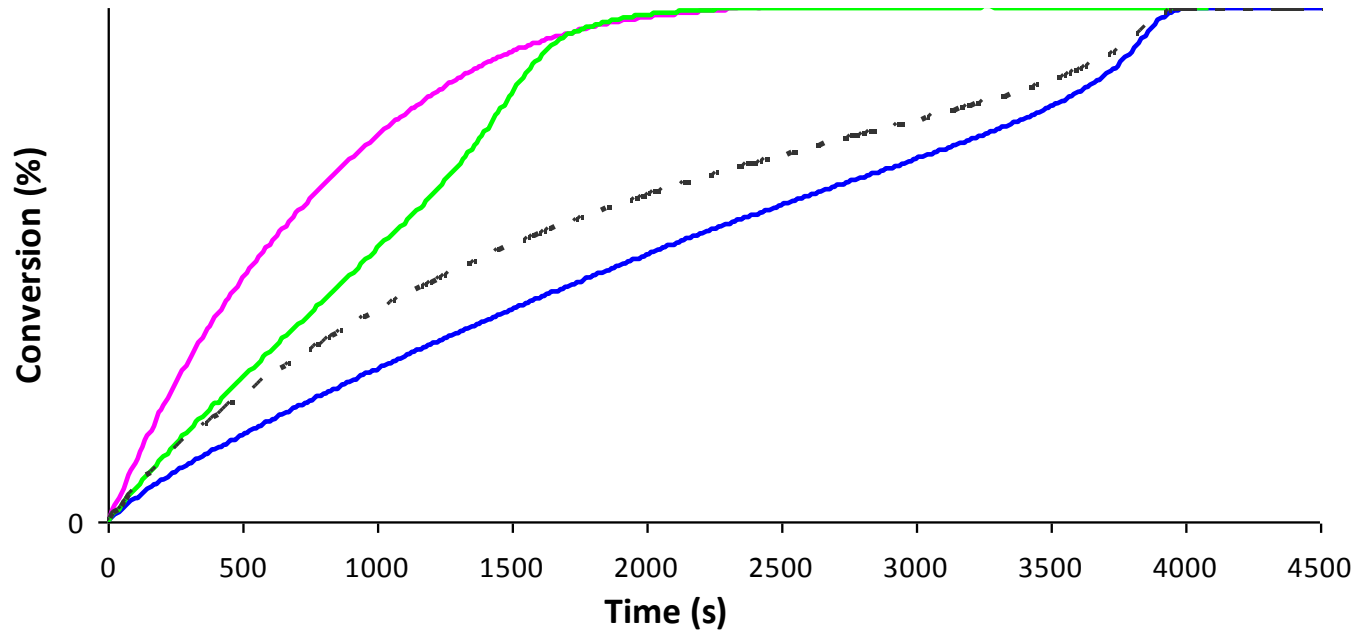
...but in detail → ADDITIVE LAW



Steam gasification: kinetic modelling

Comparison 75%beech-25%wheat straw model an
experimental blend

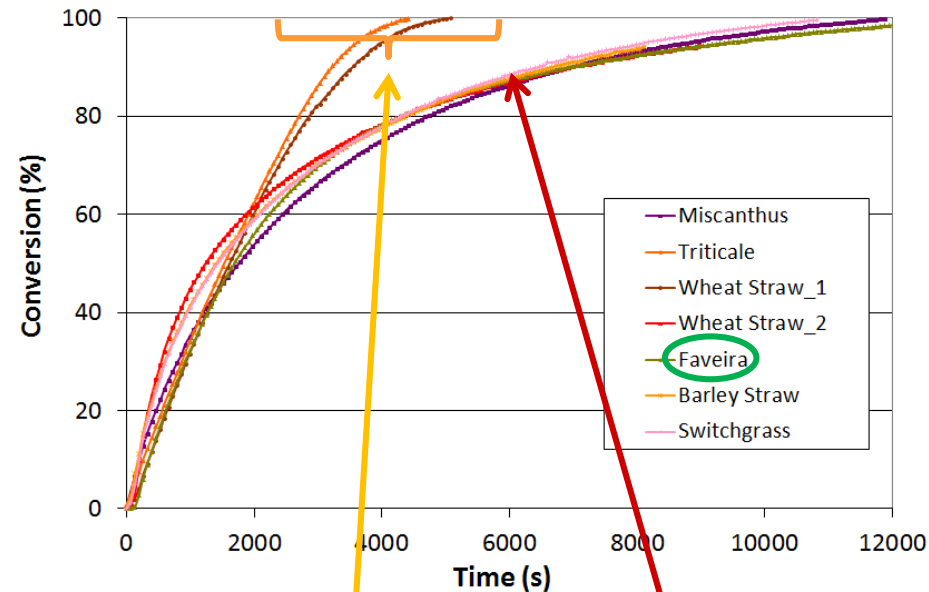
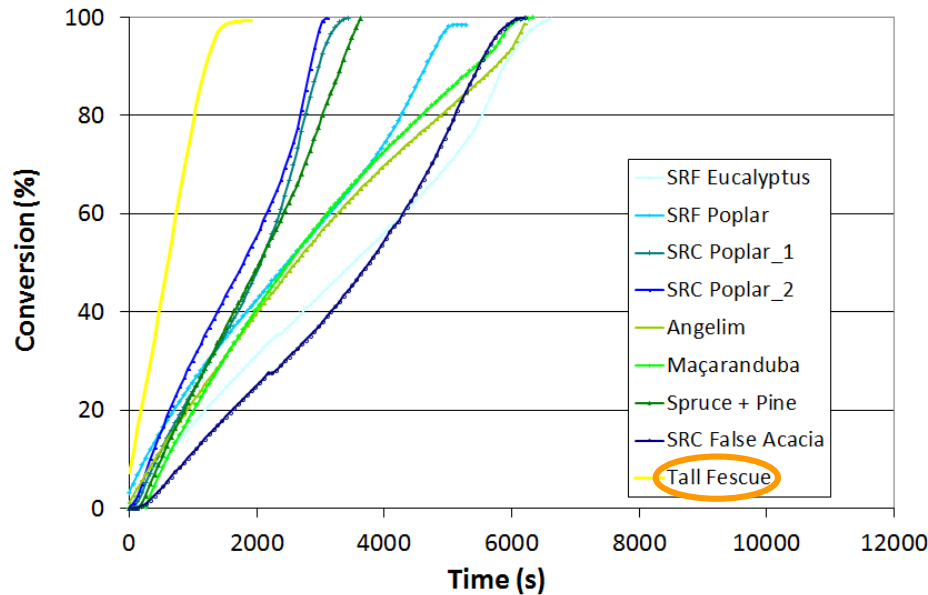
- Beech char
- Wheat straw char
- Chars blend
- - - Model



ADDITIVE LAW



Steam gasification: kinetic modelling



Constant

Increase

Wood

Rate evolution

At low conversions

At high conversions

Wrong!

Constant

Moderate decrease

Moderate decrease

Strong decrease

Agricultural biomass

Steam gasification: kinetic modelling

Experimental curve is accelerated comparing to model



Synergetic effect linked to inorganic matter?



Parameter to be considered: (K/Si)

$$(K / Si)_{BLEND} = \frac{\%_{BEECH} \cdot K_{BEECH} + \%_{WHEATSTRAW} \cdot K_{WHEATSTRAW}}{\%_{BEECH} \cdot Si_{BEECH} + \%_{WHEATSTRAW} \cdot Si_{WHEATSTRAW}}$$

Conclusions and outlook

➤ Conclusions

- Torrefaction → ADDITIVE LAW
- Steam gasification → NO ADDITIVE LAW → $(K/Si)_{\text{BLEND}}$ to be considered

➤ Outlook

- Model biomass blends behaviour → inorganic matter influence in steam gasification → parameters
- Other ratios
- Other types of biomass

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in Grenoble!**

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GRAZIE MILLE!! THANK YOU!!

MERCI BEAUCOUP!! MUCHAS GRACIAS!!

If you have any questions or want more details, please contact:

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